

White Paper

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Grant Number: PF-230278-15

Project Title: Designing a New Climate Control System for a National Historic Landmark

Project Director: Jessica Zullinger, Zullinger Preservation Consulting

Grantee Institution: Tudor Place Historic House & Garden

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Summary

Tudor Place is a National Historic Landmark located in the Georgetown Historic District in Washington, D.C. The original 8-1/2 acre city block on which Tudor Place was built was purchased in 1805 by Thomas Peter, a prominent Georgetown merchant and landowner, and Martha Parke Custis Peter, granddaughter of Martha Custis Washington. Occupied by six generations of the Peter family until 1983, the rare continuity of family ownership and stewardship over almost 200 years is reflected in the architecture, landscape, archive, and collection of Tudor Place.

This HVAC planning project was designed to bring fifteen years of planning for improvements to the museum's collections care and environmental conditions to the schematic design level in preparation for entering the construction phase. Focusing on critically needed improvements to the museum's existing climate control system (which consists solely of a gas-fired boiler and 1914 steam pipe and radiator system providing heat but no cooling), it represents a critical first step in the implementation of a site-wide Master Preservation Plan. An interdisciplinary team was assembled to design a new heating and cooling system that could serve the museum house and historic garage. Assisted by the museum's existing data on environmental conditions and prior studies that identified building and environmental needs and recommended goals, the mechanical engineer developed recommendations for a new HVAC system, allied energy reduction programs such as conversion to LED lighting, and schematic installation drawings that aimed to minimally impact historic fabric, while meeting the differing climate control needs of buildings, collections, visitors, and staff.

Project Background

Tudor Place is a National Historic Landmark located in the Georgetown Historic District in Washington, D.C. The original 8-1/2 acre city block on which Tudor Place was built was purchased in 1805 by Thomas Peter, a prominent Georgetown merchant and landowner, and Martha Parke Custis Peter, granddaughter of Martha Custis Washington. Occupied by six generations of the Peter family until 1983, the rare continuity of family ownership and stewardship over almost 200 years is reflected in the architecture, landscape, archive, and collection of Tudor Place. The institution's extraordinary collection – buildings, landscape, objects, and archives – provides unusually comprehensive documentation of the site and its Washington, D.C. context. The collections is a rich resource for interpreting the social, political, economic, and material history of Georgetown and the Federal City as well as the major events that shaped the nation.

The museum house was design by Dr. William Thornton, architect of the first United States Capitol, and incorporates two early wings constructed about 1794 into a five-part Palladian plan that was completed by the Peters, based on designs by Thornton, in 1816. Improvements to the home made by successive generations of family members include updated service areas and the introduction of new technologies, such as the 1914 steam heat system that is still in use today.

The historic garage building sits just west of the house on the existing 5-1/2 acre property. The original portion of the garage was completed in 1914 to accommodate the family's automobiles with room above for staff living quarters. The building was expanded in the 1960s to incorporate a bomb shelter, additional staff living space, and an artist's studio for Armistead Peter, 3rd, the owner of Tudor Place at that time.

With a property serving upwards of 25,000 visitors a year, and a collection including 15,000-plus objects, more than 350 linear feet of manuscripts, photographs, and ephemera, and 5,000 books and periodicals, the climate needs are diverse and challenging. The existing heating system consists of a gas-fired boiler located in the basement of the garage building, which supplies steam radiators in the garage and the museum house through a tunnel and buried steam pipes that connect the two buildings. Today, the museum house is open to the public six days a week, and houses not only exhibit space but staff offices and significant collections storage. The garage is home to Tudor Place's extensive education programs, as well as additional collections storage, staff offices and living quarters for the property's live-in caretaker. These diverse uses have equally diverse climate needs, but the antiquated heating system has only two zone controls and no humidity control. The lack of air conditioning is equally problematic in the hot, humid summers of Washington, D.C.

As early as 2000, Tudor Place began developing strategic goals for the assessment and conservation of the site's cultural resources. Conservation assessments followed, culminating in 2008 with the engagement of consultants in buildings conservation, collections care, passive climate controls, fire detection/suppression, and mechanical systems to develop a comprehensive and sustainable Master Preservation Plan. The development of the Master Plan incorporated feedback from stakeholders including neighbors, the State Historic Preservation Office, National Park Service, and the Old Georgetown Board of the U.S. Commission of Fine Arts. The Master Plan development included an assessment of existing climate and storage conditions, and this study, along with Tudor Place's operating policies, existing climate data, and industry standards set by the American Association of Museums, the American Association for State and Local History, and the Secretary of the Interior's Standard for the Treatment of Historic Properties, guided the development of the current HVAC planning project.

Dovetailing with the need to improve climate conditions for collections storage was the desire to improve sustainable practices across the site, and to lower energy consumption and costs. Tudor Place had undertaken a number of passive climate control measures, including installing interior energy panels and UV filters on windows in the museum, weather stripping and caulking doors and windows on all buildings, and installing digital thermostats to better control the existing heating system. Low-energy LED light bulbs were installed where existing fixtures would allow, and computers and other non-essential equipment were turned off at night for energy conservation and fire safety. Still, the inefficiencies of the existing heating system and the opportunity to design a new system with the specific goal of reducing the site's energy usage represents a tremendous opportunity to create a historic site that embraces the past and looks to the future.

Project Description

The Tudor Place Master Preservation Plan includes provisions for moving offices and collections storage out of the museum house, the construction of a new, below-grade object and archive collections storage facility at the garage building, and the renovation of the interior of the garage to create temporary exhibit spaces, updated and expanded education facilities, and efficient staff office space. The relocation of collections to a climate-controlled, fireproof facility is an essential goal in Tudor Place's long-range plan. The removal of ancillary activities from the museum house also will allow more of the historic home to be interpreted and accessible to the public, further supporting the institution's mission. The HVAC planning process, therefore, was aimed at designing a system that would serve the museum and garage as the buildings evolved under the Master Plan.

This project was a year-long planning effort aimed at designing a new climate control system that would serve the 1816 National Historic Landmark museum house and garage buildings. The project team consisted of:

- Curt Wilsey, Quantum Engineering Co., PC (specialists in designing HVAC systems for historic buildings)
- Mary Kay Lanzillotta, Hartman-Cox Architects (consulting architectural firm Tudor Place's Master Preservation Plan)
- Jessica Zullinger, Zullinger Preservation Consulting (historic preservation support services and project management)
- Mark Hudson, Executive Director, Tudor Place
- Grant Quertermous, Curator, Tudor Place
- Kris Barrow, Collections Manager, Tudor Place

The initial site visit at the start of the project allowed Quantum Engineering to review site conditions and meet with Tudor Place staff and the rest of the consultant team. During this visit, staff and consultants developed a detailed project timeline, set initial goals for all participants, and reviewed existing site conditions and climate requirements. The following list of deliverables for the project was established for the mechanical engineer to work towards:

1. Identify possible HVAC equipment layouts and establish the basis of design for the systems.
2. Prepare heating and cooling load calculations.
3. Prepare an energy model to predict operating costs.
4. Summarize operating and maintenance costs.
5. Identify possible lighting upgrades to minimize HVAC loads.
6. Identify possible envelope upgrades to minimize the HVAC loads.
7. Provide first costs estimates.
8. Provide mechanical system component details and product cut sheets.

Over the next few months, architectural drawings, historic floor plans, utility usage invoices, several years of climate data from the museum (gathered via HOBO Dataloggers), visitation and occupancy statistics, a complete survey of existing light fixtures including bulb type and wattage, security system information, and maintenance and operations records were gathered by the team to inform the design process. Quantum Engineering reviewed building plans, mapped existing system components and layouts for potential integration into the new system, and reviewed climate requirements for

each room of the two buildings

Establishing goals for the desired project deliverables was essential to ensuring that the planning process delivered a system design that would meet the needs of Tudor Place. These goals were as follows:

- Maintain as much of the house and garage basements for interpretation as is practical.
- Minimize energy consumption.
- Remove the steam boiler and radiators from services. Retain fixtures for posterity (radiators in situ in the museum) whenever practical.
- Reuse ductwork and grilles where practical.
- Provide year-round temperature and humidity stability as appropriate for each classification of the collection and configure the systems to be sympathetic with the historic character of the house within the limits of the building envelope.

During early concept design work on the Master Preservation Plan, Tudor Place's team of consultants identified a geothermal system as a likely option for the property. The project team, therefore, focused intensively on assessing whether geothermal was the right system for the site. Considerations such as costs, energy efficiency, space requirements, longevity, and impact on historic resources, including landscape and trees, were examined. The unique aspects of installing a geothermal system, including the need for test wells and soil analysis, the well drilling process, and the size and type of potential mechanical components were key elements examined by the team.

Because each building serves a variety of functions, including exhibit rooms, archive and collection storage, offices, and meeting spaces, a key element in designing the new system was assigning climate control classification levels to each room. The museum desired to implement sustainable preservation practices, so a broad view was taken of temperature and humidity set points, which is also in keeping with current American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) guidelines. This allows the house museum to achieve stable conditions for the collection while avoiding damage to the equally important building envelope. Otherwise, if humidification is added and operated at elevated indoor levels, moisture damage within the envelope becomes likely. Therefore, temperatures would be allowed to fluctuate through a broader range in order to stabilize humidity. Humidity control would be provided for the most sensitive spaces. Each room was assigned an ASHRAE Class A, B, or C profile to establish the climate parameters necessary for the space, and the system designed accordingly. The parameters of these ASHRAE profile can be found in the *ASHRAE Handbook for Museum, Galleries, Libraries, and Archives*.

The need for multiple climate zones favored a Variant Refrigerant Flow (VRF) system, which has the added benefit of using refrigerant-based piping and thereby reduces the danger of water leaks in sensitive spaces. A Dedicated Outside Air System (DOAS) was planned for each building and air intake locations identified. Because VRF systems do not allow for a wide range of filtration options, the higher air cleaning needs of the museum (MERV 15 for the ASHRAE Class A spaces) would require additional filtration. This was solved by using an air-handler with filtration for the DOAS system, thereby treating the outside air on its way into the buildings.

Institutional Collaboration

To help Tudor Place and the project team anticipate potential challenges or considerations in installing and operating a new geothermal system, the project team identified other historic house museums that had installed, or planned to install, similar systems. This proved to be an extremely valuable part of the process, as it allowed the team to ask questions of the staff about the project's impact, operations and maintenance, and ongoing experiences that might not be fully considered by system designers or installers. It was particularly valuable to identify a nearby site that was slightly ahead of Tudor Place in installing a geothermal system. The geological information they had already learned from drilling a test well was valuable in calculating the size of equipment and number of wells Tudor Place might need.

Allied System Planning

A lighting survey for the two buildings played an important role in properly sizing the new system. Staff and consultants made a room-by-room record of light fixtures, including ceiling and wall fixtures as well as table, floor, and desk lamps. Bulb number, type, and wattage were noted, as well as whether bulbs were exposed or shielded, and any unusual aspects of the fixture - particularly historic lamps that often have uniquely shaped shades or bulb housings. One of the major goals of the project was to improve energy efficiency, and so the mechanical engineer made recommendations for low-energy LED bulbs to fit each specific type of fixture, taking into account exposed bulbs in historic spaces that would require visually appropriate bulbs. This simple survey allowed load calculations for the HVAC system to be modeled on the lowered heat output of LED bulbs, and lowered overall costs as reduced energy usage was taken into account. Alongside the lighting analysis, Quantum Engineers also examined areas where the exterior envelope of the buildings could be upgraded to lower the HVAC load by installing insulation or improving window conditions.

System Layout and Integration

The second half of the planning process focused on laying out the system and its integration into the

existing structures. A new mechanical space would be required in the garage for the central mechanical plant. System components were laid out in both buildings. In the museum house, existing ductwork serving a portion of the first floor was incorporated into the new system, thereby preserving an element of the building's mechanical history and reusing existing resources. Each duct, vent, and return was carefully mapped and an appropriate location identified for each room and passage. This took considerable time in a site visit that involved accessing every inch of both buildings to locate appropriate paths for new equipment. In several areas of the museum, existing pipe chases were identified and purposefully reused to avoid the need to channel into the home's solid masonry interior walls. The team remained mindful of plans for a new fire suppression system and upgraded security throughout the project so that these systems could be integrated alongside the HVAC system.

The final stage of the project was review and refinement of the system design, from which Quantum Engineers created their final report – a process that extended from June through September 2016, as each component of the project was reviewed, questions asked and answered, and decisions made. Finally, draft reports were reviewed during several team conference calls in September and October, producing a very thorough final report from Quantum Engineering that incorporated each of the proposed project goals into a document that serves as the schematic plan for a new HVAC system and its installation.

Outcomes

The primary objective of the HVAC planning project was to develop a recommendation for a new HVAC system, including all components and specifications, and to create a schematic plan for the installation of that system in the garage and museum house. At the end of the project, Quantum Engineering prepared a final report which addressed each of the project objectives and provided a thorough schematic design plan that provided a framework for Tudor Place's Master Preservation Plan planning and fundraising and set the stage for development of construction documents. The final report includes the following elements:

1. Project Report
 - Process and Deliverables
 - Environmental Sustainability
 - Overview of Existing Mechanical Systems
 - Goals for Proposed Mechanical System Upgrades
 - Proposed Temperature and Humidity Conditions

- Sources of Heating and Cooling (Geothermal Wells, Humidifiers, Air Distribution, Piping Distribution, Sources of Outdoor Air, Dehumidification)
 - Thermal Envelope Improvement Recommendations
 - Electrical Requirements
 - Fire Protection Considerations
 - Additional Controls and Recommendations
 - Project Phasing Comments
 - Air Filtration
 - Energy Consumption and Basis of Design
2. Calculations – HVAC Zones and Loads by Building
 3. Mechanical System Comparison
 4. Set Points and Goals
 5. Cost Estimates
 6. Lighting Upgrade Recommendations and Cut Sheets
 7. Mechanical Cut Sheets for System Components
 8. Drawings
 - Installation Floor Plans for each Building
 - Schematic Details for Air Handling Units and Dedicated Outside Air System

This detailed report allows Tudor Place to begin planning other systems, such as fire suppression and security, more accurately pursue fundraising goals for the Master Preservation Plan project, and provides plans and specifications that can readily be converted into construction documents when groundbreaking commences. The planning process funded by this grant has produced a complete design for a critical component of a large and complex preservation project on a significant historic resource.

Lessons Learned

While the HVAC planning project was successful, there were lessons learned that can be applied to increase efficiency and ensure a successful outcome in future projects. Key lessons learned during this project include:

- The involvement of the museum's collections and curatorial staff was essential in determining the environmental needs of each space. The data they provided was collected over time in advance of the planning project. From this we were able to identify the areas with the most sensitive collections items or building fabric and create a ranking matrix for

each room. Using the ASHRAE parameters and classification system helped to describe and rank the climate needs of each space.

- Incorporating existing infrastructure into the new system, such as the existing steam tunnel connecting the garage and museum house, steam pipe chases, and ductwork in the museum, minimizes disruption to historic fabric.
- Giving some forethought to integrating planning activities for other systems and future project components into the project can avoid future problems and ensure that systems install logically and will fit in the spaces designated. Here, looking at the relationship of LED lighting and the HVAC system load specifications, and considering how fire suppression and security systems might fit into the same mechanical spaces, lays the groundwork for the next steps in moving towards a comprehensive construction project.
- The fact that the planned collections and storage facility will be located below grade means that the typically high level of energy use in these tightly controlled spaces is greatly reduced. While this design element is specific to this project, identifying these types of advantages in any project's design assists in planning and in promoting the project to key decision makers and donors.
- Collaboration with other institutions is a helpful component of planning a complex project. Their project experience can provide information pertaining to system design elements that work well in the house museum setting, pitfalls which might be avoided, or helpful items to include in the planning process.
- Gathering an interdisciplinary team of experts with specific experience in historic buildings, and the type of building you are working with, is very important to the success of the project. A challenge to working with a consultant team can be communication and timing. In this case, the principal consultant was not local, so site visits and meetings had to be carefully pre-planned to be efficient and cost-effective. Establishing a project timeline at the outset, and adjusting it every few months to keep the team on track was helpful, as was establishing a regular schedule for team conference calls. Since the bulk of the deliverables in this project fell to one consultant, it was also important to make sure that the rest of the team provided needed materials or information in a timely manner to avoid delays in creation of the design and report documents.